strange places in which they are found. For these fresh-water creatures, the common inhabitants of lakes and ponds, are to be found in brackish ditches, sea-pools, the mud of ponds, the dust of gutters, in tufts of moss, on the blades of wet grass, in the rolled-up leaves and in the cups of liver-worts, in the cells of *Volvox*, the stems and sporangia of *Vaucheria*, in vegetable infusions; on the backs of *Entomostraca*, on their abdominal plates, on their branchial feet; on fresh-water fleas, wood-lice, shrimps, and worms; in the viscera of slugs, earth-worms, and Naiades; and in the body-cavities of *Synaptæ*.

But the great variability of every part of the external and internal structure of the Rotifera points to their fitness for playing the parts of cosmopolites. See how in *Floscularia* and *Stephanoceros* the head and its appendages are so developed that they dwarf all the rest; how in *Apsilus* the trunk predominates; while in *Actinurus* both head and trunk become appendages of a huge foot. The corona diminishes continually from the large complex organs of *Melicerta*, *Hydatina*, and *Brachionus*, down to the furred face of *Adineta* and the tuft of *Seison*, and vanishes altogether in *Acyclus*. The antennæ can be traced from long infolding or telescopic tubes, furnished with setiferous pistons, special muscles, and nerves, through a succession of shorter and simpler structures, till they become mere pimples or even setiferous pits in the body surface. The skin is hardened into a perfect lorica in *Brachionus*, is partially hardened in *Dapidia*, is merely tough in *Mastigocerca*, and is soft and quite unarmed in *Notommata*. The appendages of the body in Pedalion rise almost to the dignity of crustaceous limbs, for they have joints, and are worked by opposing pairs of muscles, passing across their cavities from point to point. In *Asplanchna* these appendages become stumpy projections, and the muscles, though still passing freely across the body-cavity, are reduced to threads. In *Triarthra* the appendages become chitinous spines; and at last, when we reach *Adineta*, *Taphrocampa*, and *Albertia*, we find that we have passed from a Rotiferon closely resembling a Nauplius-larva to one that is a simple worm.

The internal structure is just as plastic. The characteristic trophi exhibit a series of striking changes as we pass from one genus to another. In one direction the change is due to the degradation of the mallei, in the other to that of the incus; and in both this degradation is pushed so far, that the changing parts may be said almost to disappear. For in *Brachionus* and *Euchlanis* the mallei are well developed; in *Furcularia*, mere needle-shaped curved rods: in *Asplanchna*, so evanescent that it is hardly possible to find them in an animal killed by pressure.

By another set of changes, the rami are in their turn reduced almost to evanescence; becoming feeble loops in *Stephanoceros*, and in *Floscularia* two membranes attached to the unci.

Changes, great in degree, if not in variety, occur also in the excreto-respiratory system. For the contractile vesicle, which fills quite half the body-cavity in some *Asplanchnæ*, dwindles down in various species till it seems to vanish in *Pterodina* and *Pedalion*; while in one abnormal form, *Trochosphæra*, the connection between the lateral canals and the contractile vesicle is snapped, and the latter becomes an appendage of the cloaca only.

The nervous system, wherever it has been made out, is indeed always on the same plan; but its central organ, the nervous ganglion, is, in *Copeus* and *Euchlanis*, a great cylindrical sac stretching from the head below the mastax; while in *Floscularia* it shrinks into a small star-shaped body between the eyes and the organ of taste.

The alimentary and reproductive systems are those which vary the least; but even here the difference, in proportionate size, is very great between the stomachs of *Sacculus* and *Synchæta*, and also between the ovaries of *Asplanchnopus myrmeleo* and *Asplanchna priodonta*.

But not only do most of the external parts and internal organs vary in turn almost to vanishing, but these variations are not in any way simultaneous. The result is, that we find an organ, of a form characteristic of one family or genus, occurring in a species that belongs to another. Thus, for instance, the trophi of the *Melicertadæ* appear in *Pompholyx*, one of the *Triarthradæ*. Nay, more; it is easy to point out Rotifera that bear some striking characteristics of two or three other genera, or even of two or three other families. *Microdon clavus*, for example, has the central mouth and double ciliary wreaths of one of the *Rhizota*, the eye of a *Notommata*, the trophi of a *Diglena*, and the foot of a *Monostyla*. Again, *Pterodina patina* has the corona of *Philodina*, the lorica and transversely wrinkled retractile foot of *Brachionus*, the foot-ending of a young Rhizotan, and the mastax of the *Melicertadæ*. Then there is Mr. Thorpe's new Australian Floscule, which swims freely like one of the *Ploïma*, has the buccal cup and wreath of *Floscularia*, the dorsal eye of *Notommata*, and the body and forked foot of *Proales*.

To sum up, we may say that in the female Rotifera, the corona, head, foot, toes, appendages of the trunk, antennæ, eyes, and contractile vesicle vary down to almost absolute extinction; while, if we include the male in our survey, we must add that even the whole of the alimentary tract may disappear also. Moreover, the characteristics of the various groups interlace in so many ways that no organ—nor, indeed, any combination of two or three organs—can be relied upon to determine with certainty an animal's true position.

Two conclusions are, in consequence, irresistibly forced on us: the first, that the Rotifera, from *Pedalion* to *Albertia*, are related by descent; the second, that their curious habitats, wide dispersion and great variations in their structure are due to causes that have been at work for a very long period of time.

One other fact has also been made clear in this review —namely, that the British Rotifera give a very fair idea of the whole class. No doubt there are many foreign species, and some of these are very remarkable, and of great interest; but the greater number fall readily enough into the divisions that contain our own species.

And indeed it is a fortunate thing that we can here, at our own doors, study so many typical forms from life. For what books or drawings can give us the delight which we derive from observing the animals themselves?

To gaze into that wonderful world which lies in a drop of water, crossed by some atoms of green weed; to see transparent living mechanism at work, and to gain some idea of its modes of action; to watch a tiny speck that can sail through the prick of a needle's point; to see its crystal armour flashing with ever-varying tint, its head glorious with the halo of its quivering cilia; to see it gliding through the emerald stems, hunting for its food, snatching at its prey, fleeing from its enemy, chasing its mate (the fiercest of our passions blazing in an invisible speck); to see it whirling in a mad dance to the sound of its own music, the music of its happiness, the exquisite happiness of living,—can anyone, who has once enjoyed this sight, ever turn from it to mere books and drawings, without the sense that he has left all Fairyland behind him?

THE DARKNESS OF LONDON AIR.

A GREAT deal has been written at various times upon the subject of London fogs.

The constitution of these London fogs has been carefully gone into by several well-known men of science, from time to time; and the results obtained are of very great interest, as they prove, amongst other things, that during the winter London air has an unusually large amount of carbonic acid in it. Dr. W. J. Russell found from experiments made in the City of London a few years ago, that on one day the carbonic acid had increased to 14·1 parts in 10,000 of air—that is, there was more than three and a half times the average amount present.

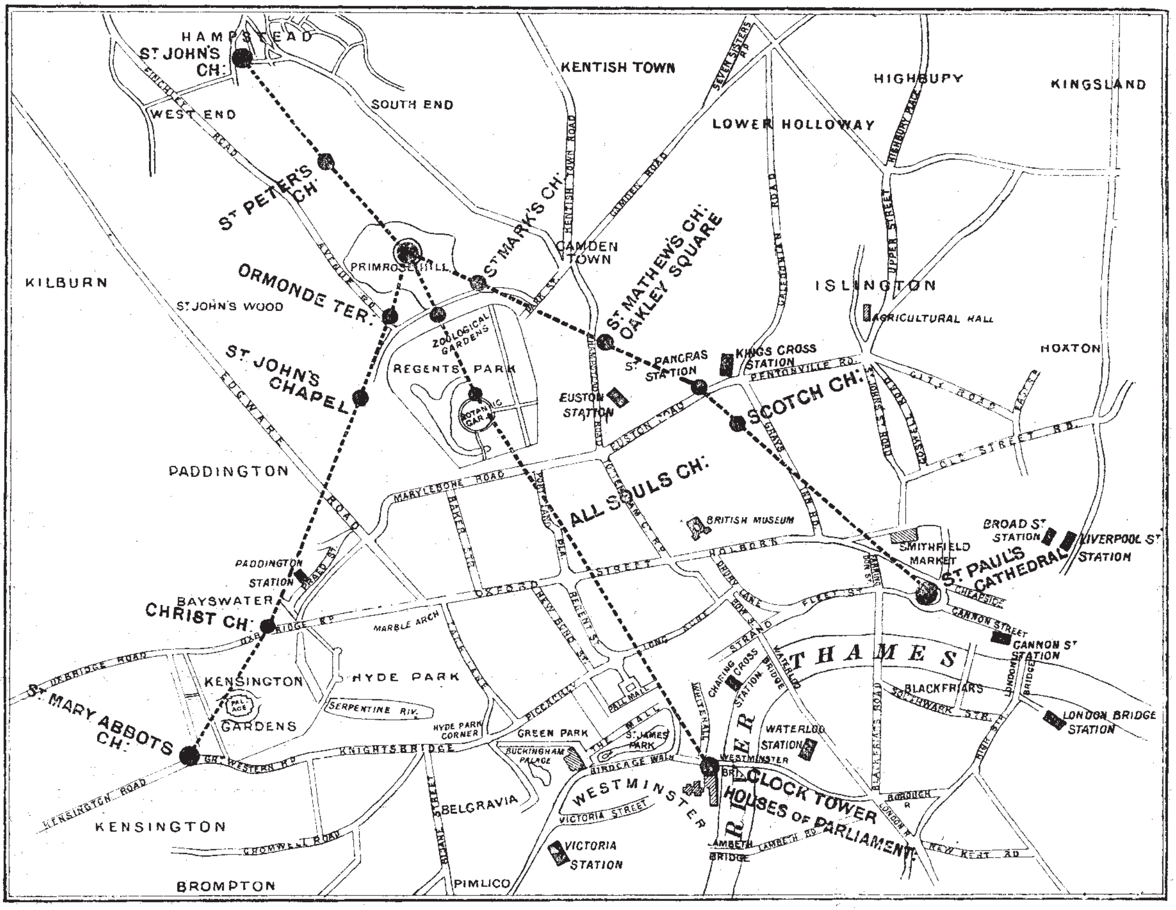
The question will naturally be asked, whether we cannot check this increase of carbonic acid in London air; and, in reply, it may be said that we can; partly by stopping the enormous volumes of sooty smoke belched out daily from hundreds of thousands of chimneys in the metropolis; and, partly, by having more open spaces, &c.

It is well known that the crowding of many people and animal life of all sorts, upon a small area of land, increases the production of carbonic acid, whether it be from respiration or from coal-burning; and it is almost indisputable that the latter produces the well-known black fogs and yellow fogs.

That these black fogs and yellow fogs—to which London and other large towns are liable in the winter—have a most injurious effect upon human beings and all animal life, and vegetation also, cannot be doubted, since we see the death-rate largely increased during the prevalence of black fogs; and of late years the more delicate plants, and indeed the strong ones, both at the Botanical Gardens, Regent's Park, and at Kew, have suffered much from the same cause.

Two things are to be briefly shown in this paper: (1) the general thickness and density of the atmosphere over London during the winter; and (2) the amount of artificial light used during the prevalence of black or dark yellow fogs in various parts of London.

SKETCH MAP OF A PORTION OF LONDON:——MEASURING POINTS SHOWN BY BLACK DOTS.



In connection with this subject various observations were taken in London during the winter of 1887–88, and the results are given below.

Before proceeding further, we may note that London was very free from fogs during the winter of 1887–88—a fact which was probably, to a certain extent, due to the light rainfall, and the unusual dryness, in consequence, of the great plain or valley of the Thames. This was the case not only in London, but in Manchester, Leeds, Liverpool, and elsewhere.

(1) As regards the general thickness and density of London air. The sketch plan of a portion of London will show that Primrose Hill—which is about 219 feet above the sea-level—was the point selected for (let us say) measuring from.

Three lines, which embraced the measuring points fixed upon, were taken over London, these lines being respectively the south-west line to St. Mary Abbot's Church, Kensington; the south line to the Clock Tower, Houses of Parliament; the south-east line to St. Paul's Cathedral. One more line was taken towards the country: this we will call the north line to St. John's Church, Hampstead. Intermediate measuring points were taken on all these lines, church spires or towers, &c., being selected as the most conspicuous objects that could be seen from Primrose Hill.

The distance of all these intermediate measuring points from Primrose Hill, and their names, are given in Table I. The *total* number of times that each of the chosen points was seen during the five months selected is also given.

It will be observed that during the 152 days which make up the five months selected, Christ Church, Lancaster Gate, and St. Mary Abbot's Church, Kensington, on the south-west line; the Clock Tower, Houses of Parliament, on the south line, and the Scotch Church, Regent's Square; and St. Paul's Cathedral, on the south-east line, were *never once* seen.

When it is known that on any ordinary fine day during the late spring, summer, and early autumn, you can see right across London, on any one of the selected lines, it will be easy to realize how thick the air over London is during the winter.

It may be noted that when you could see as far as St. John's Church, Hampstead, it would, as a rule, have been possible to see much further, but since there was no point beyond Hampstead which could be taken as a measuring point, it was impossible to record the distance.

(2) As regards the amount of artificial light used in various parts of London owing to the prevalence of dark fog. The observations given below were made, with the assistance of various friends, during the winter of 1887-88, and give the approximate result in hours.

TABLE I.—*The distances given in this Table are all measured approximately from Primrose Hill.*

	South-west line to St. Mary Abbot's Church, Kensington.				South line to the Clock Tower, Houses of Parliament.				South-east line to St. Paul's Cathedral.					North line to St. John's Church, Hampstead.	
Distance from Primrose Hill.	¼ mile.	¾ mile.	2 miles.	3 miles.	¼ mile.	¾ mile.	1¾ mile.	3 miles.	¼ mile.	1 mile.	1½ mile.	1¾ mile.	3¼ miles.	¾ mile.	1½ mile.
Name of Measuring Point.	South end of Ormonde Terrace.	St. John's Chapel, Marylebone.	Christ Church, Lancaster Gate.	St. Mary Abbot's, Kensington.	North side of Zoological Gardens.	North side of Botanical Gardens.	All Souls' Church, Langham Place.	Clock Tower, Houses of Parliament.	St. Mark's Church, Regent's Park.	St. Matthew's Church, Oakley Square, N.W.	Clock Tower, St. Pancras Station.	Scotch Church, Regent's Square.	St. Paul's Cathedral.	St. Peter's Church, Belsize Park.	St. John's Church, Hampstead.
November 1887	11	13	0	0	10	14	0	0	19	6	0	0	0	12	9
December 1887	18	13	0	0	17	13	0	0	25	4	1	0	0	8	11
January 1888	18	8	0	0	17	9	1	0	25	1	0	0	0	6	2
February 1888	5	22	0	0	3	24	0	0	22	3	2	0	0	3	21
March 1888	31	31	0	0	31	30	1	0	30	1	0	0	0	8	23
Total number of times each point was seen... ...	83	87	0	0	78	90	2	0	121	15	3	0	0	37[1]	66

On nine days you could not see 100 yards. On four days you could not see 5 yards.

A few districts out of many others are given in Table II.

TABLE II.—*Observations taken in London.*

District in London in which the register was kept.	1887.		1888.			Total number of hours during which artificial light was used.
	Nov.	Dec.	Jan.	Feb.	March.	
Fenchurch Street, E.C.	13½	1¾	29	0	3½	47¾
Southwark Street, S.E.	27¼	1½	20½	0	2¼	51½
Grosvenor Gardens, S.W. ...	17¾	0	35	0	2½	55¼
Oakley Square, N.W.	19½	5	13	0	3	40½
New Cavendish Street, W. ...	23½	2	26	0	1½	53
Notting Hill Gate, W.	19	0	15	0	2¼	36¼
Homerton, E. ...	34¼	24¼	38¼	4¾	11½	113

The manner in which the observations (given in Table II.) were made will be seen in detail from Table III., which was kept by Mr. E. Liddell at the College, Homerton, E.

This table is given because Homerton suffered more from darkness than any other part of London, owing, it cannot be doubted, to the large number of factories in the neighbourhood. It will be seen later on in this paper that Leeds suffered more from darkness than the other provincial towns selected, and this was due probably to a great extent to the same cause.

From Table II. it will be seen that January was the worst month for dark fogs, the average for each of the districts given being 27 hours of darkness per month.

London is not much worse than our large provincial towns in respect to dark fogs. Table IV. gives the results of observations made in several towns.

It will be seen from Table IV., that dark fog was general in the tabulated towns during the month of January. It is said that Manchester, of late years, has been unusually free from dark fogs, owing to the fact that a very large number of mills have been moved out, so as to escape the heavy town rates, &c. The ordinary white fog has also been reduced, probably through thousands of acres of the wet morass lands on the west side of Manchester having been well drained recently. This being the case, something might be done to improve the drainage of the marshes to the east of London.

---

[1] On thirty-six days this point could not be seen.

Presuming that dark fogs are principally due to smoke,—and Sir Douglas Galton, in a paper read at the Parkes Museum in 1887, on "The Cause and Prevention of Smoke," declared that black (or dark) fog was *entirely* the result of smoke, while Dr. Marcet attributes the density of London fog *mainly* to smoke—it is clear that we want legislation to intervene, and to extend the Metropolitan Acts of Parliament, viz. those of 1853 and 1856, and instead of allowing these Acts to deal only *partially* with factory smoke, to cause them to be applied to every house in London.

TABLE III.—*Fog Observations from November* 1, 1887, *to March* 31, 1888.

NOTE.—Two spaces will be found below for every day during the five months. When, owing to the prevalence of fog, artificial light is used on a particular day, put a × in the *first* space assigned to that particular day; and in the *second* space put the quarters of an hour or number of whole hours and quarters during which light is used.

	NOVEMBER.		DECEMBER.		JANUARY.		FEBRUARY.		MARCH.	
	Denote days by ×.	Duration of time in hours.	Denote days by ×.	Duration of time in hours.	Denote days by ×.	Duration of time in hours.	Denote days by ×.	Duration of time in hours.	Denote days by ×.	Duration of time in hours.
1	...	...	×	1½						
2	...	...	...	...	...	...	×	4¾		
3	...	...	...	...	×	1				
4										
5										
6										
7										
8	...	...	×	2¼						
9	...	...	...	...	×	1				
10	...	...	×	2	×	8				
11	...	...	×	5½	×	8				
12	...	...	×	4	×	5½				
13	...	...	×	1½	×	4				
14	...	...	...	...	×	2¼				
15										
16	×	9¼								
17										
18	×	8								
19	×	2½								
20	×	1¼	...	...	×	4½				
21	×	6¼	...	...	×	2				
22	×	2¼	...	...	×	½				
23	...	...	...	...	...	...	...	...	×	6[1]
24	×	1½								
25										
26	...	...	...	...	...	...	...	...	×	1[2]
27	...	...	...	...	...	...	...	...	×	4½[3]
28	×	1								
29	×	2¼								
30	...	...	...	...	×	1				
31	...	...	×	7½						
		34¼		24¼		38¼		4¾		11½

Grand total = 113 hours.

TABLE IV.—*Observations taken in Provincial Towns.*

Name of Town in which the register was kept.	1887.		1888.			Total number of hours during which artificial light was used.
	Nov.	Dec.	Jan.	Feb.	March.	
Leeds	18½	12	47	4	0	81½
Liverpool	6½	8¼	26¼	3¾	0	44¾
Manchester ...	16	20	37	0	3	76

It is not necessary to quote any figures here, to prove how the death-rate in London rapidly increases during the prevalence of smoke fogs, as everyone knows it too well. But we may give an extract from the *Gas World* to show the enormous and quite unnecessary cost of these smoke fogs.

The *Gas World* says that, "during the foggy days which were experienced between the 16th and 24th of November 1887, the Gas Light and Coke Company sent out to its customers in London no less than 710,251,000 cubic feet of gas; that to manufacture this quantity 71,000 tons of coal must have been carbonized, and that the total value of the gas, without the consideration of the by-products, is £106,000. During the nine days, therefore, the public paid the Gas Light and Coke Company no less than £490 per hour for *artificial light*."

This calculation, it should be observed, does not include the amount supplied by other Gas Companies in London during the same short period of fog.

W. HARGREAVES RAFFLES.

ELECTRICAL STRESS.[1]

THE subject of the discourse was brought before the members of the Royal Institution some years ago by Mr. Gordon. In the interval a considerable amount of work has been done upon it, both in England and Germany, and many experiments have been devised to illustrate it. Some of the more striking of these, though of great interest to the student, are rarely or never shown in courses of experimental lectures. The lecturer and Mr. C. V. Boys, F.R.S., last year devised a set of apparatus which has made the optical demonstration of electrical stress comparatively easy, and most of the results obtained by Kerr and Quincke can now be demonstrated to audiences of a considerable size. Before discussing this portion of his subject the lecturer introduced it by an explanation of principles on which the experiments are founded.

Magnetic lines of force can easily be mapped out by iron filings, but the exhibition of electrical lines of force in a liquid is a more complex matter. In the first place, if two oppositely electrified bodies are introduced into a liquid which is a fairly good non-conductor, convective conduction is set up. Streams of electrified liquid pass from the one to the other. The highly refracting liquid phenyl thiocarbamide appears to be specially suitable for experiments on this subject. If an electrified point is brought over the surface a dimple is formed which becomes deeper as the point approaches it. At the instant at which the needle touches the liquid the dimple disappears, but a bubble of air from the lower end frequently remains imprisoned in the vortex caused by the downward rush of the electrified liquid from the point. It oscillates a short distance below the point, and indicates clearly the rapid motions which are produced in the fluid in its neighbourhood. When the needle is withdrawn a small column of liquid adheres to it. This effect is, however, seen to greater advantage if a small sphere about 5 mm. in diameter is used instead of the needle-point. When this is withdrawn a column of liquid about 5 mm. high and 2 mm. in diameter is formed between the sphere and the surface. A similar experiment was made by Faraday on a much

---

[1] Fog not dense on March 23, but very dark.
[2] Darkness, rather than fog, from 2.45 to 3.40.
[3] Fog and darkness.

[1] Abstract of a Lecture delivered at the Royal Institution on February 15, by Prof. A. W. Rücker, F.R.S.